ALEGRA-HEDP THREE-DIMENSIONAL SIMULATIONS OF Z-PINCH APPLICATIONS

Christopher J. Garasi[a]

[a]Sandia National Laboratories
Albuquerque, NM 87185-0819
cjgaras@sandia.gov

Researchers at Sandia National Laboratories have devised a new method that dramatically decreases the solution time for the eddy current approximation to Maxwell's equations. This advance has significant impact on magnetohydrodynamic (MHD) simulations of environments generated within Sandia's Z-machine. The Z-machine uses tremendous amounts of electrical current to convert wire arrays into plasma, which is then collapsed onto a cylindrical axis (Z-axis) by magnetic forces in order to generate large amounts of radiation.

Advances in understanding Z-pinch physics over the past 10 years have opened new and exciting avenues both experimentally and computationally. The complexity associated with the dynamics of wire-arrays from individual wire ablation to wire-wire interaction have only recently been observed in experiments. The details of three-dimensional effects (e.g. wire precursor ablation and stagnation, array mass left behind, current density redistribution, multiple stagnation) have a significant impact on the total radiation output. Perturbations arising from non-uniform azimuthal wire spacing are believed to have a 30% impact on radiated power. This lack of detailed understanding impacts the size of required facilities for inertial confinement fusion, which translates into a multi-million dollar impact on required budgets.

To date, no numerical simulation has attempted to simulate the dynamics of wire arrays (including the impact of the machine's current return structure) in three dimensions. ALEGRA-HEDP has begun to simulate this environment, having produced the highest fidelity, two-dimensional simulations of wire-array precursor ablation to date. Our three-dimensional code capability now provides us with the ability to iteratively solve for the magnetic field and current density distribution associated with both the wire array and the complex current return structure. New insight is being obtained on the impact that experimental viewports (e.g. slots in the current return can and radial spokes) have on the magnetic field surrounding the array.

The impact that the perturbed magnetic field has on idealized plasma liner dynamics will be discussed. Results from three-dimensional ALEGRA-HEDP simulations of this environment will be presented.

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